Science and Technology
Understanding Structures and Mechanisms

Elementary – Strong and Stable Structures

TEACHER'S RESOURCE GUIDE

Uncover the mysteries of the CN Tower while learning about the importance of form, function, strength, and stability to a structure's design and construction.

Discover the CN Tower and the various factors that had an impact on its design. Explore the city from above and search for the answer to various curriculum linked questions.

Bookings include:

- An educator's guide with pre and post visit activities to tie your class outing back to learning in the classroom
- Self-guided tour of the CN Tower including the Main Observation and Outdoor Observation levels
- Curriculum linked worksheets
- Lunch options available

The Grade 3 and 5 - Strong and Stable Structures program explores the five "Big Ideas" as outlined in the Ontario Curriculum and relates these to the CN Tower itself:

Big Ideas	**CN Tower Program Content**
A structure has both form and function	The CN Tower was built as a communication tower to transit radio signals above all of the other tall buildings being built in the city of Toronto (primary function). The architects wanted to build something that would be able to showcase the great advances in Science and Technology being developed in Toronto, while at the same time providing locals and tourists with spectacular views of the city. This became the secondary purpose of the CN Tower, to provide observation levels for viewing the viewing the city below. The CN Tower is a tall, triangular shaped building with 2 "pods" towards the top that house the various observation levels (form).
Structures are affected by forces acting on them	The CN Tower was to be taller than any other in the world and was to hold the weight of visitors as well as a variety of equipment. Wind, rain, lightning, and weight were among the various forces that would need to be considered in the design and construction of the CN Tower.
Structures need to be strong and stable to be useful	To be useful as a communications tower with Observation levels for the public, the CN Tower had to be strong enough to stand tall in one fixed spot. It was built so tall to account for the possibility that the city may someday construct buildings even taller than those already built.
Measuring forces informs the design of structures and mechanisms	The CN Tower was modelled in wind tunnels and through calculations before any concrete was poured to be ensure it could withstand the potential forces of wind, temperature, and gravity acting on it.
Natural forces have an effect on society and the environment	The CN Tower has, in numerous studies, been shown to have altered the lightning strike frequency in the local area.

Arrival Instructions

Groups are to access the CN Tower via Bremner Blvd, one block south of Front St West, between York St and Spadina Ave. Bus drop off and pick up is located on the north side, westbound lanes on Bremner Blvd. From the curb it is a short walk to the main entrance.

All guests must pass through our security screening, which includes the use of metal detectors and a bag check.

Upon arrival at the CN Tower, your group will be asked to wait outside while the teacher or group leader checks in at the Group Desk (open seasonally – please check in at Guest Services Desk if Group Desk is unavailable).

When you check in you will need to provide:

- Actual number of students and chaperones
- Final payment for your group (unless prepayment has been arranged in advance)

You will be given ONE ticket for each person in your group, which are to be distributed prior to elevation.

Your group will be directed to the elevators that will take them to the observation levels.

What to Bring

Please ensure that students bring a pen or pencil to write with and something to write on (ie: a clipboard or binder). There is an on-site gift shop for those who forget to bring a writing utensil with them.

On-Site Facilities

The CN Tower does not offer lockers or storage for students while on-site. Students are asked to bring only what is needed as they will have to keep their belongings with them at all times.

Dining - The CN Tower offers a variety of dining options including Le Café at the base of the CN Tower. Student group meal and snack packages can be ordered in advance, or students can order and pay on-site.

Completing the Assignments

Each student will have a set of worksheets that make up the Assignment to be completed while on-site at the CN Tower. Answers to the assignment questions can be found in written information about the CN Tower and other structures on the walls throughout the CN Tower (starting on the mezzanine level before the students board the elevators), and in the views of the city from the Observation Levels.

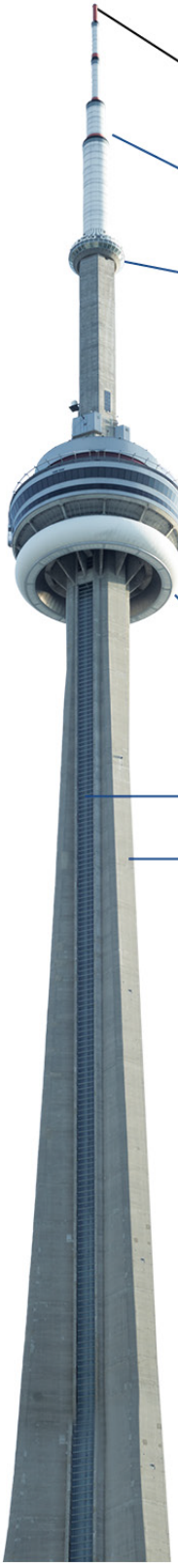
The entire visit, from arrival to departure, should take approximately 1.5 – 2 hours. Add another 45 minutes if you plan on having lunch at the CN Tower as well.

Facts at a glance

Construction
- Started on February 6, 1973
- Antenna finished on April 2, 1975
- Opened on June 26, 1976
- 1537 workers helped build

Materials
- Total weight = 117,910 metric tonnes or 130,000 tons
- Volume of concrete = 40,524 m^3 or 53,000 cubic yds
- 998 km or 620 miles of post-tensioned steel cables
- 4,535 metric tonnes or 5,000 tons of reinforcing steel
- 544.2 metric tonnes or 600 tons of structural steel
- Radome: Teflon-coated fibreglass membrane

Tower by the numbers
- 1976-2010: World's Tallest Tower, Building and Free-standing structure
- Over 1.9 million annual visitors
- 1776 stairs
- 8 public elevators
- 8 cables per elevator car
- 58 seconds to reach the observation level
- 22km/h - top speed of the elevator
- 360 Restaurant revolves every 72 min
- 75 lightning strikes per year



Name:

Date:

Full height
553.33m | 1,815ft 5in | 181 storeys

Antenna

The Top
447m | 1,465ft | 147 storeys

EdgeWalk
356m | 1,168ft | 116 storeys

360 Restaurant
351m | 1,151ft | 115 storeys

Main Observation
346m | 1,136ft | 114 storeys

Lower Observation
342m | 1,122ft | 113 storeys

Radome

Elevator Shaft

Tapered Legs

DID YOU KNOW

The CN Tower currently holds two Guinness World Records!

Pre Visit Preparation

Prior to your visit to the CN Tower it is recommended that you review the following list of vocabulary with your class:

Word	Definition
Centre of Gravity	The point around which an object's mass is equally balanced in all directions. The total mass of the object is concentrated at this point.
Form	The shape of something.
Function	The action for which a person or thing is specially fitted or used or for which a thing exists.
Stability	The ability of a structure to stay fixed in one spot.
Strength	The ability of a structure to support a load.
Structure	Something built or constructed, usually for a specific purpose; a supporting framework with a definite size, shape, and purpose that holds a load.

Answer Key: The following are a *brief* and longer answer for each question. Use them as a guide when reviewing student answers.

1. **Why was the CN Tower built and why is it so tall?**
   For radio and TV broadcast, to broadcast over other tall buildings. The building boom in the 1960s meant more tall buildings. Radio and TV used antennas to receive incoming signals. A new communications tower was needed that would be taller than any other building.

2. **If you were an architect designing the CN Tower, what three natural forces should you consider before building?**
   Wind, Temperature and Gravity. The Tower would need to stable enough to withstand the force of wind from any direction, which is why its symmetry is so important. The concrete and steel had to withstand the cold of winter and the heat of summer, expanding and contracting over time. No matter what it was made from, a tall structure like the CN Tower was going to weigh a lot and that would need to be considered in it's construction and structure. In our case, the CN Tower has a low centre of gravity, with tapered legs to reduce weight at the top and reduce the force of wind. Bonus answer: Lightning, for which the Tower has cables running the from the antenna to the ground, letting lightning strikes dissipate into the ground.

3. **What materials were used to make the CN Tower? How do these make it a strong and stable structure?**
   Concrete, steel and glass. Concrete is very dense and strong, able to resist compression from all the material above it. Steel is strong but can flex, allowing it to give when temperatures change. Post-tensioned cables, which run the full height of the Tower, pull the concrete down on itself, combining the strength of concrete and the flexibility of steel. Together, they help the Tower resist wind forces and keep it standing tall.

4. Draw some unique features of the CN Tower. What do you think their purpose is?

Our Radome, the donut shaped bubble at the bottom of our main pod. This holds our broadcast antennas. *The tapered legs* provide strength while also reducing weight as the Tower grows in height. *Our glass fronted elevators*, which let guests see out on their ride up and down. *The tall, unobstructed antenna* on the top of the concrete core, which is higher than any other building in Toronto, allowing reception and broadcast of many signals from all over Ontario and beyond.

5. There are many different types of structures, each with its own unique size, shape, and function (ie: a house provides shelter, a bus provides transportation). List 3 different types of structures that you can see from our observation levels. State what each structure is used for.

(Below are several options)

An Arch – The Humber River bridge, the Rogers Centre, to provide support over a long span.

A GO Train – Transportation.

A Ferry **–** Transportation, floatation

Wind turbine – catching wind to generate electricity

6. Create your own unique structure! What is it made of and what is its function?

For their own interpretation! More to prepare for post-visit activities, to take advantage of potential inspiration from objects seen from the view.

Post Visit Activities

1. **Design and Build** Divide the class into teams of 3-4. Have each team design and build a bridge or tower than can hold a load (ie: the bridge must be able to hold the weight of 3 wooden blocks or toy cars, the tower must be able to hold the weight of a golf ball or Styrofoam ball). Provide the students with a variety of materials to build their structure (ie: paper, newspaper, empty egg cartons, straws, tape, glue, Popsicle sticks, string, and playdoh). Students can prepare a written or verbal report of their project.

2. **Research and Report** Have each student select 3 different towers or 3 different Wonders of the World and prepare a written report on the similarities and differences between them, when they were built, their purpose, what design features make them strong and stable.

3. **Stability Exercise** Ask the class to stand with their feet together, then with their feet apart. Which stance provides better balance? Ask the students to try different stances to identify what spacing between their feet feels most stable. Once seated again, ask the class to identify items in the class and their neighbourhood that have wide a base for stability and note them on a flipchart or chalkboard (bike, skis, swing set, traffic pylon). How can kids apply this knowledge in gym class, soccer, hockey or gymnastics?

4. **Math** Measure yourself and identify how many of you it would take to be as tall as the CN Tower. (Height of CN Tower divided by your own height = x).

5. **Building Competition** Have a competition in your class to see who can build the tallest structure. Working with a partner, provide each team with 50 straws, 50 paper clips, tape, and scissors. Give the students 1 hour to complete the task of building the tallest structure using the materials provided. At the end of the hour measure each structure to determine which is the tallest. To increase the difficulty, use a fan to test the stability.

6. **Testing the Strength of Shapes** To test the strength of various shapes you will need Popsicle sticks and glue. Ask students to make a square using 4 popsicle sticks, a triangle using 3 popsicle sticks. Stand the shape on a (flat) end and push the top with a finger. Which is stronger?

Online Resources and Books

http://www.great-towers.com/
World Federation of Great Towers – provides information on towers around the world

http://www.pbs.org/wgbh/buildingbig/index.html
https://www.pbslearningmedia.org/collection/structures/
A great website with a variety of teaching tools and fun learning activities including

- *Interactive labs* that allow students to experiment with forces, materials, loads, and shapes
- *Online challenges* that gives students an opportunity to virtually fix and build a variety of structures including a bridge, a dome, a skyscraper, a dam, and a tunnel
- A Wonder of the Worlds databank
- Interviews with engineers
- An *educators guide* with planning ideas and hands on activities (try the Newspaper Tower)

http://www.youtube.com/watch?v=JBpUZH5bZ_E
"Measure the height of any object" - A YouTube video on how to make your own height measuring gadget using every day materials.

http://www.greatbuildings.com/
A great resource for types of structures, images and history of famous buildings, bridges and other structures.

http://www.pbslearningmedia.org/resource/arct14.sci.dsrise/high-rise/
Fun activity has students building a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan.

http://www.wonderclub.com/AllWorldWonders.html
Complete listing of world wonders (including ancient, medieval, natural modern, underwater wonders)

Wild buildings and bridges: architecture inspired by nature
Kaner, Etta author.; Wiens, Carl, illustrator. Toronto, ON: Kids Can Press, 2018
Celebrates natures influence on buildings and bridge design from around the world. Activities make for an interactive experience that puts learners in scientist's seat.

Build it up
Cross, Gary Markham, ON: Scholastic Canada, 2008.
A focus on big ideas in structures. Detailed photographs and diagrams. An emphasis on hands-on exploration.

Designs in Science: Structures
Morgan, Sally, and Adrian Morgan. New York: Facts on File, 1993.
Colorful photographs and interesting facts and figures compare structures found in nature with those built by people. Diagrams and hands-on activities explain basic physical science principles such as forces and load.

The Random House Book of How Things Were Built
Brown, David J. New York: Random House, 1992.
Detailed, cutaway illustrations tell the stories of great structures throughout history and across the globe. Diagrams explain the basic principles behind these engineering feats.

Experiment! Spiderwebs to Skyscrapers: The Science of Structures
Darling, David. New York: Dillon Press, 1991.
Simple explanations, large photographs, and hands-on activities explore foundations, materials, arches, trusses, and structures.